STORM DRAINAGE

DESIGN

STORM DRAINAGE DESIGN

STORM DRAINAGE DESIGN REQUIREMENTS

In order that the Engineering Department may adequately review preliminary plats, construction plans and stormwater management plans, the following items should be indicated or accounted for on all plans submitted for approval:

D-1 All storm drainage facilities shall comply with the requirements as stated in the Stormwater Management Program for the City of Greenville and the North Carolina Division of Water Quality Stormwater Best Management Practices Manual.

D-2 Storm drainage pipes to be designed for a 10-year storm (post development), catch basins to be designed for a 2-year storm (post development).

D-3 Minimum storm drainage size is 15 inches.

D-4 Double basins are permitted.

D-5 Minimum allowable velocity is 2.5 feet per second for concrete pipe or corrugated metal pipe. Maximum velocity is 10 feet per second within a system. Exiting velocities shall be in conformance with the Sedimentation and Erosion Control Ordinance of the City of Greenville or the latest version thereof.

D-6 Drainage pipes which are located parallel or near parallel to public streets shall be contained within street rights-of-way. If this is not possible, dedicated storm drainage easements shall be required as defined on STD. NO. 15.01.a.

D-7 In cases where two ditches intersect at perpendicular or obtuse angles, erosion control measures must be indicated.

D-8 Headwalls or flared end pipe will be required at the influent and effluent of all pipe systems.

D-9 Indicate all ditch sections with centerline elevations at least every 50' and cross sections if there is a significant change in the profile.

D-10 Indicate topography, ditches, pipes, swales, and drainage easements which are adjacent to the proposed project.

D-11 Catch basins shall be placed such that the depth of flow in the gutter is based on allowable spread. Spread shall be 8' on all city streets. Maximum depth of flow in the curb and gutter for all streets shall never exceed 6".

GENERAL NOTES:

~~1. FOR STREAMS CARRYING 500 ACRES OR MORE OF SURFACE RUNOFF, THE EASEMENT REQUIREMENT IS TO BE THE WIDTH OF THE STREAM FROM TOP OF BANK TO TOP OF BANK, PLUS (+) 10' ON EACH SIDE OF STREAM. (40' MINIMUM WIDTH)~~

1\. ~~2.~~ FOR OPEN CHANNELS THE MINIMUM EASEMENT MUST CONTAIN THE WIDTH OF THE STREAM FROM TOP OF BANK TO TOP BANK. PLUS (+) 10' ON EACH SIDE OF STREAM.

2\. ~~3.~~ WIDER EASEMENT WIDTHS MAY BE REQUIRED FOR PIPE DEPTHS GREATER THAN ~~TEN~~ EIGHT FEET.

3\. ~~4.~~ PIPE SYSTEMS AND OPEN CHANNELS ON PRIVATE PROPERTY conveying stormwater from multiple properties SHALL BE PLACED IN A STORM DRAINAGE EASEMENT.

Easement Requirements for Open Storm Drainage Channels

Area in Acreage	Easement Requirement
0–45 ac.	20'
45–120 ac.	30'
120–500 ac.	40'
~~500 ac.+~~	~~see note~~

Easement Requirements for Storm Drain Pipe

Pipe Size	Easement Requirement
15"	15'
18"	15'
24"	15'
30"	20'
36"	20'
42"	25'
48"	25'
54"+	30'MIN (VARIES)

NOT TO SCALE

MINIMUM DRAINAGE EASEMENT REQUIREMENTS FOR STORM DRAIN PIPES AND OPEN CHANNELS

STD. NO.	REV
15.01A	

D-12 Will all storm drainage designs, the following design data must be submitted for each run of pipe.

a. Area drained

b. Design storm intensity adjusted for duration

c. Design flow

d. Coefficient of runoff

e. Grade of pipe

f. Type of pipe

g. Size of pipe

h. Velocity of flow

i. Maximum capacity

j. Hydraulic grade lines

D-13 Not more than one acre may drain in the street at a single concentrated point.

D-14 Slotted drains are permissible (STD. NO. 25.03) with prior approval of the Engineering Division.

D-15 The minimum grade for any storm drainage pipe shall be 0.3%. In the event that this requirement cannot be met, the City Engineer may approve an alternate provided the minimum velocity of 2.5 ft/sec is met.

D-16 Any storm drainage system to be city-maintained shall have "Record Drawings" submitted and approved prior to scheduling a pre-final street acceptance inspection. All "Record Drawings" for storm drainage infrastructure shall include, but not necessarily limited to, the information as identified in the *Street and Storm Drainage "Record Drawings" Submittal Requirements.*

D-17 Maximum distance between manholes/boxes shall be 300' ~~[illegible]'~~.

REQUIREMENTS FOR INSTALLATION OF REINFORCED CONCRETE PIPE

1. AASHTO Designation M86 (or the latest revision) shall apply to all reinforced concrete pipe.

2. All pipe installed within the street right-of-way shall be Class III or higher.

3. The appropriate sealant shall be applied to both inside and outside of joints of pipe 24" in diameter and larger. Joints shall be wiped smooth.

4. A roughness coefficient of 0.013 ("n" factor) shall be used in the design of reinforced concrete pipe drainage systems.

REQUIREMENTS FOR INSTALLATION OF CORRUGATED METAL PIPE

1. AASHTO Designation M196 or the latest revision thereof shall apply.

2. All corrugated metal pipe shall be aluminum unless coating of steel pipe is approved by the City Engineer.

3. Coupling bands shall be used at all joints and shall be of a size specified by the manufacturer in accordance with the pipe design. Bands shall conform to AASHTO Designation M196. Bands to be of Hugger-Type or approved equal.

4. Pipes shall meet the NC-DOT specifications for loading requirements.

5. A roughness coefficient of 0.024 ("n" factor) shall be used in the design of corrugated metal pipe drainage systems.

COMPACTION AND BACKFILLING

Compaction for reinforced concrete pipe and corrugated metal pipe to be in accordance with NC-DOT Standard Specifications for Roads and Structures.

STORM WATER DESIGN CALCULATIONS

RUNOFF DETERMINATION:

There are two acceptable methods: (1) Rational Method (good for areas less than 20 acres and minor design systems) and (2) Soil Conservation Service Method using Curve Numbers.

DETERMINATION OF DISCHARGE:

The most widely used method for determining discharge in storm drainage is the Rational Method and shall be the method used for the purpose of this manual. It should be noted, however, that this method should be used with caution since it does not adequately recognize all of the complications of the runoff process. The basic formula may be reduced to "Q=CIA", where:

Q = Discharge, in cubic feet per second.

C = "Runoff" coefficient, unitless

I = Intensity of rainfall, inches per hour

A = Drainage basin area, acres.

These factors are explained in detail in the following paragraphs.

C.....RUNOFF COEFFICENT

The runoff coefficient is the proportion of the total rainfall which runs off the basin area into the drainage system. The runoff coefficients to be used for the Greenville area are listed on Chart No. SD-3.

I.....INTENSITY

Values for the rainfall intensity for the Greenville area may be derived from Chart No. SD-1 and SD-2. The design procedures for runoff for the City of Greenville shall be based on a 10-year rainfall and the time of concentration (Tc).

$Tc = [(L^3/H)^{0.385}]/128$

L = Maximum length of travel time of water (feet)
H = Difference in elevation between the most remote point on the basin and the outlet (feet)

NOTES: Overland flow, grass, multiply Tc by 2.
Overland Flow, concrete or asphalt, multiply Tc by 0.4
Concrete channel, multiply Tc by 0.2

A.....DRAINAGE BASIN AREA

The drainage basin area can be calculated with the use of topographic maps by marking the basin ridgeline and planimetering the designated areas. When marking the basin ridgeline, it should be remembered that water runoff flows perpendicular to contour lines.

Q.....DISCHARGE

After determining the coefficient of runoff, rainfall intensity, and drainage basin area; the discharge can be computed by the use of rational formula "Q=CIA".

CATCH BASIN DESIGN

DESIGN PROCEDURE:

The following procedure for the location and design of catch basins for the City of Greenville is based on the actual hydraulic characteristics of the standard catch basin for the City as depicted in Chart No. SD-4. Catch basin design shall be based on a t-year storm. Double basins are permitted. The catch basin data sheets, Chart SD-5 or approved equivalent shall be completed and submitted with each plan.

1 – DETERMINE DRAINAGE LIMITS:

The drainage limits should be calculated by the use of topographic maps by marking the basin ridgeline. It should be noted that the centerline of the streets will usually represent a ridgeline on a normal crown.

2 – DETERMINE DEPTH OF FLOW:

The depth of flow allowed is the depth of the water in the gutter line which will be tolerated in flooding conditions.

3 – DETERMINE LONGITUDINAL SLOPE (S_L) OF THE STREET:

Determine the slope of the street in percent.

4 - DETERMINE TRANSVERSE SLOPE (S_T) OF THE STREET:

This can be determined from the typical section of the street and will usually consist of the vertical distance from the gutter line to the crown of the street divided by the horizontal distance from the gutter line to the crown of the street.

5 - DETERMINE CAPACITY OF THE BASIN:

The capacity of the basin can be determined by the chart on Chart No. SD-4. Enter the bottom of the chart with the transverse slope and draw a vertical line to the longitudinal slope. Then, using this as a turning point, draw a horizontal line to intersect the "K" factor. Then use the equation:

$Q = KD^{1.67}$, where:

Q = the capacity of the basin in cubic feet per second
K = a dimensionless factor determined from said chart
D = the depth of flow in the gutter line in feet

With this information, complete columns 1, 2, 3, and 4 of the catch basin design data sheet (Chart SD-5).

6 – DETERMINE AREA SERVED BY THE BASIN:

STEP NO. 1: Assume a trial coefficient and a trial intensity for the design area and place these figures in columns 5 and 6 of the data sheet. At this point, an approximate area served by the catch basin may be determined by dividing the catch basin capacity by the trial coefficient of runoff and the trial intensity (column 5 x column 6). This derived area should be placed in column 7 in the design data sheet. This gives an approximate area served by the catch basin. With this area and topographic lines, a trial location of the proposed basin should be made.

STEP NO. 2: To insure that the location as derived in Step No. 1 is appropriate and that the trial coefficient of runoff and trial intensity are in order, the runoff for the area determined by the proposed location of the basin should be calculated. This is accomplished by calculating the runoff as established in the storm water design procedures listed in the previous section and completing columns 8 through 13. If column 13 varies by more than 10% from column 7, this would indicate that the trial coefficient and/or trial intensity were not in line with the actual coefficient and intensity, and therefore, the basin is not properly located. The procedure in Step No. 1 should then be repeated and then adjust the trial coefficient of runoff (col. 5) and trial intensity (col. 6) accordingly. Once all the basins have been properly located, the pipe design associated with the basins may be completed according to the PIPE SYSTEM DESIGN PROCEDURES listed in this chapter.

CULVERT DESIGN

DESIGN PROCEDURE:

There are two steps in storm drainage design. The first step is to determine the amount of water discharged at the point of design. This can be accomplished by using the "Storm Water Design" section of this manual. The second step is the actual selection of a size for the structure, based on the calculated discharge.

DETERMINE OF STRUCTURE SIZE:

There are essentially two types of control which must be considered in every culvert design situation: inlet control and outlet control. Both types of control must be considered separately in the design of culverts.

INLET CONTROL:

Inlet control exists in cases where the culvert is not flowing full. The inlet control charts (SD-a through SD-f) have headwater depth as the controlling criteria. Headwater depth is the depth of the water on the upstream side of the culvert, expressed in diameters of the pipe under study.

The maximum allowable headwater is limited by either the controlling flood elevation or existing or proposed development. However, the maximum headwater depth should not exceed 1.2 times the open height of the culvert for a 10-year storm.

OUTLET CONTROL:

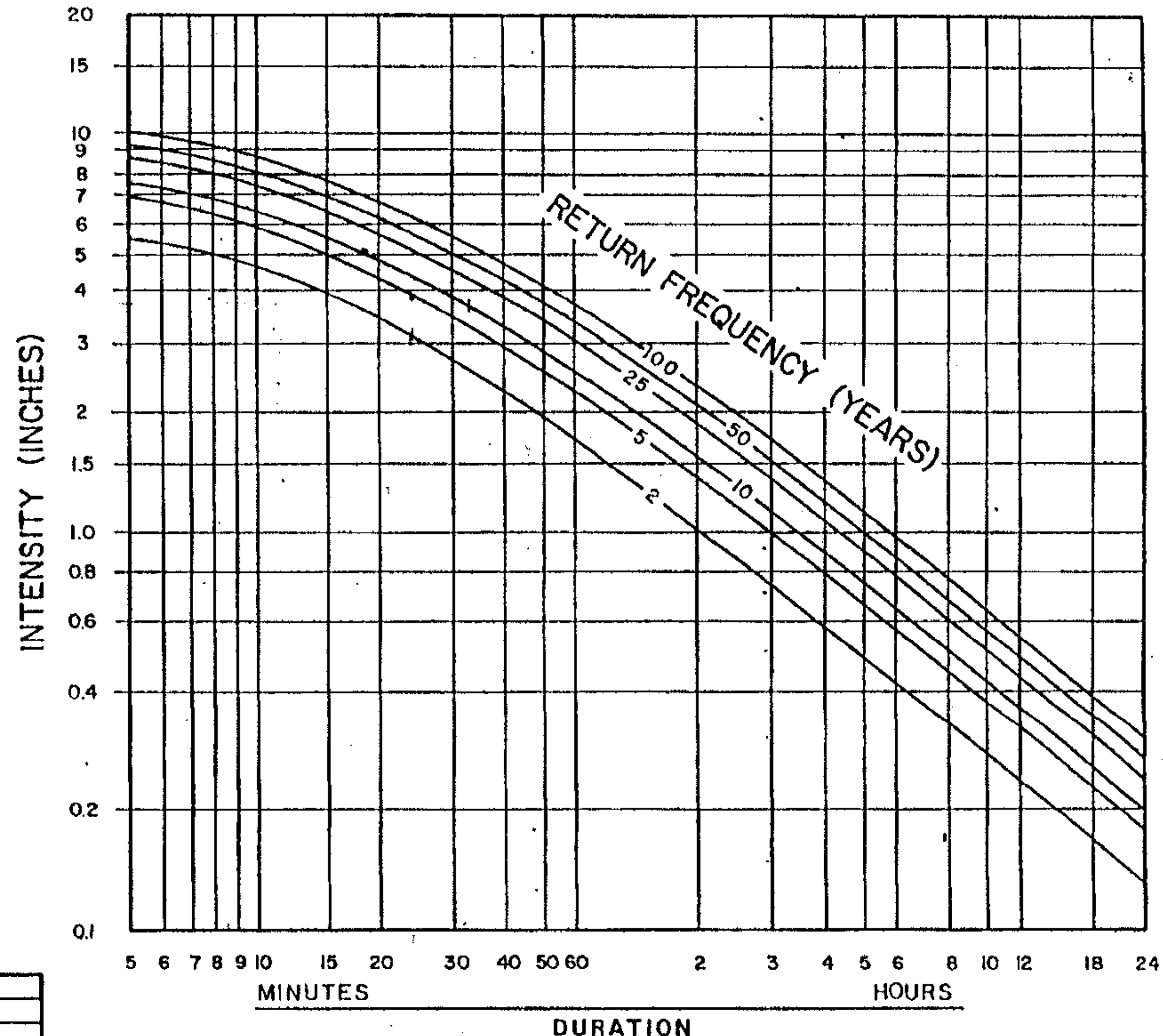
Outlet control exists in cases where the culvert is flowing full. Before using the outlet control charts (SD-g through SD-m), it is necessary to determine the coefficient of entrance loss "Ke". These values are found in the coefficient of entrance loss table on Chart No. SD-7.

A controlling criteria for outlet control is tailwater depth, which is represented in the tables by the amount of "head". Head is the difference in elevation of the water surface on the upstream side of the culvert and the downstream water surface. The tailwater elevation is determined by downstream conditions and may be calculated if these conditions are known. In any case, the tailwater elevation will not be below the design year flood elevation at the outlet. If flood data is not available, the assumption may be made that the tailwater elevation is the crown of the culvert.

PIPE SYSTEM DESIGN

Once all the catch basins have been located according to the catch basin design procedures, the next step is to design the pipe systems to serve the basins. For the purpose of this manual and for the City of Greenville, pipes within the system shall be designed to carry a 10-year storm (post development). The sizing of these pipes shall be based on the Manning Equation. It should be noted that the velocities for the pipes shall be maintained between 2.5 feet per second and 10 feet per second. In addition, points of discharge should be treated in such a manner to conform with the State and local ordinances on velocity controls. This design is based on the sum of the individual areas served by the catch basins and not the sum of the capacities of each basin. The Storm Drainage Design Data Sheet, Chart SD-6, or an approved equivalent, should be completed and submitted with each plan.

CHART SD-1



NOTE: ASSUME TIME OF CONCENTRATION EQUALS DURATION

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RAINFALL INTENSITY VS. DURATION

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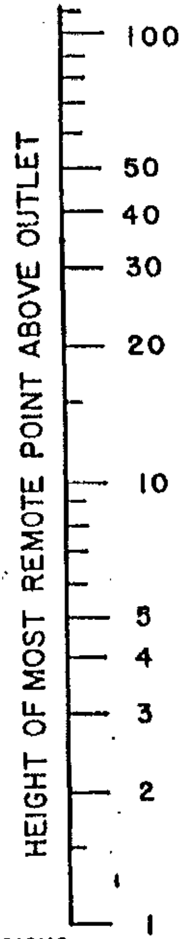
STD. NO.	REV.
15.12	

CHART SD-2



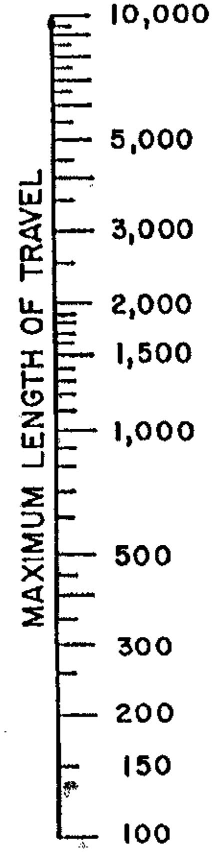
USE NOMOGRAPH T_c FOR NATURAL BASINS WITH WELL DEFINED CHANNELS FOR OVERLAND FLOW ON BARE EARTH, AND FOR MOWED GRASS ROADSIDE CHANNELS.

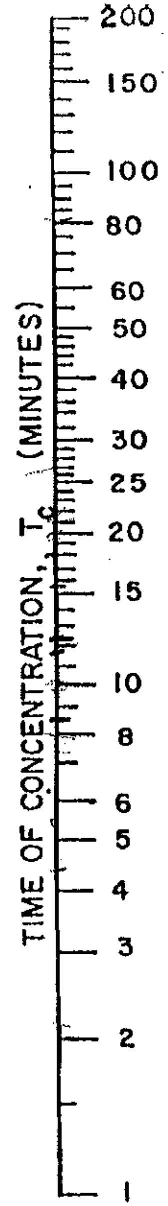
FOR OVERLAND FLOW, GRASSED SURFACES, MULTIPLY T_c BY 2.

FOR OVERLAND FLOW, CONCRETE OR ASPHALT SURFACES, MULTIPLY T_c BY 0.4

FOR CONCRETE CHANNELS, MULTIPLY T_c BY 0.2

$$T_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$





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15.13	

RUNOFF CO ICIENTS

LAWNS:	(1) SANDY SOILS	FLAT	< 2%	0.10
		AVERAGE	2% – 7%	0.15
		STEEP	> 7%	0.20
	(2) HEAVY SOILS	FLAT	< 2%	0.15
		AVERAGE	2% – 7%	0.20
		STEEP	> 7%	0.30

WOODS, CEMETERIES, PARKS	0.20
UNIMPROVED AREAS (PASTURE, CROP, ETC.)	0.25
PLAYGROUNDS	0.30

Keep 3 catagories.

RESIDENTIAL:	(1) APARTMENTS AND TOWNHOUSES	0.70
	(2) LOT SIZE < 1/4 ACRE (R-6, R-9)	0.60
	(3) LOT SIZE < 1/3 ACRE (R-15)	0.55
	(4) LOT SIZE < 1/2 ACRE (R-20)	0.50
	(5) LOT SIZE < 1.0 ACRE	0.40
	(6) LOT SIZE > 1.0 ACRE	0.35
INDUSTRIAL:	(1) LIGHT	0.70
	(2) HEAVY	0.80
COMMERCIAL:	(1) DOWNTOWN, STRIP, MALL, PAVEMENT AREAS	0.95
	(2) CENTER	0.90
	(3) NEIGHBORHOOD	0.85

ROOF:	0.95	
PAVEMENT:	(1) Asphalt or concrete	0.90
	(2) Brick	0.80
GRAVEL:	0.80	

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CHART SD-3

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RUNOFF COEFFICIENTS

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15 14	

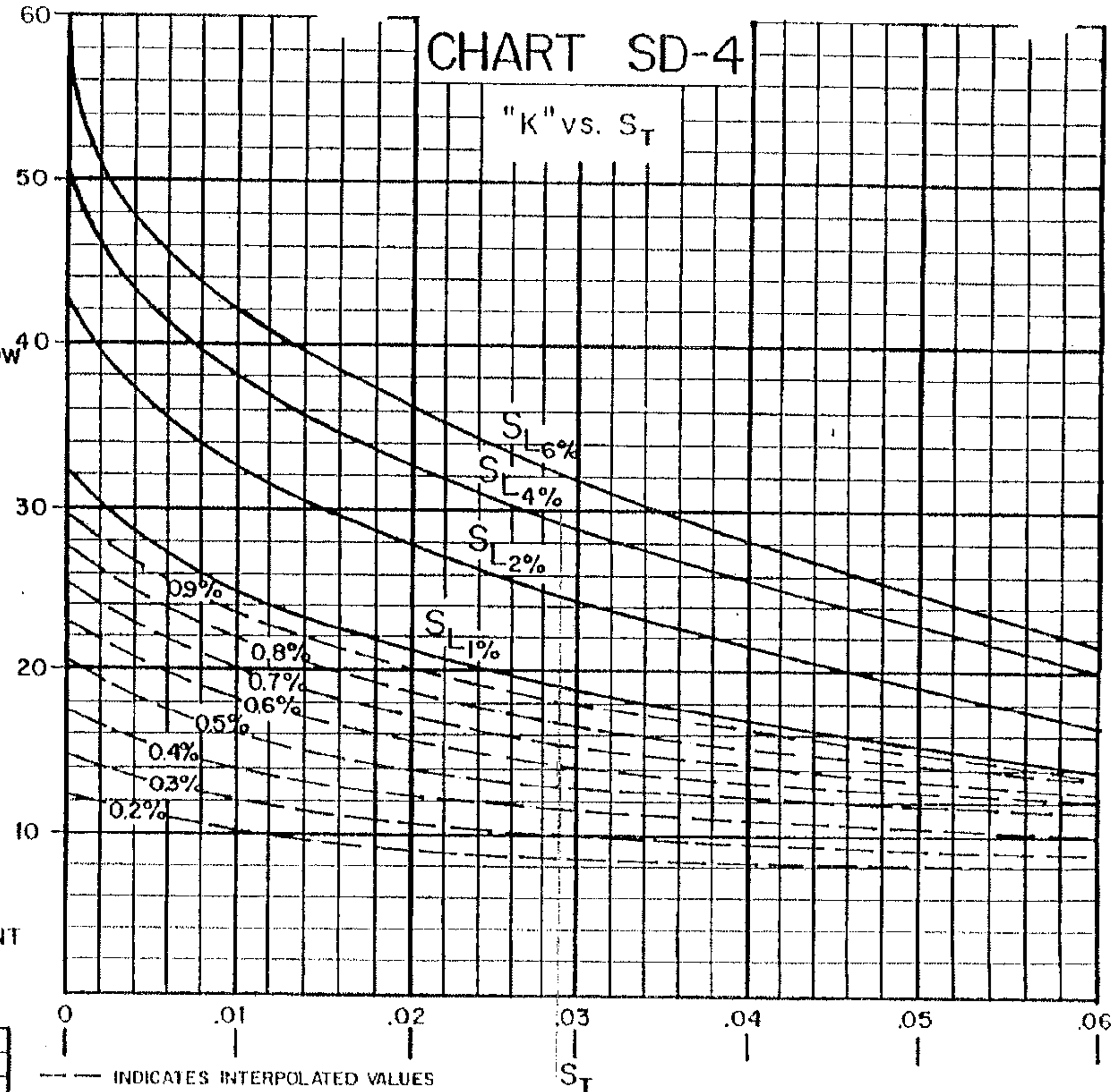
CAPACITY OF BASIN =

$$Q = K D^{5/3}$$

WHERE:

Q = C.F.S.

D = Depth of gutter flow in feet



S_L = LONGITUDINAL GUTTER SLOPE

S_T = TRANSVERSE GUTTER SLOPE

K = GRATE INLET COEFFICIENT

— — INDICATES INTERPOLATED VALUES

S_T = VERTICAL DISTANCE FROM CROWN TO GUTTER LINE DIVIDED BY DISTANCE FROM CREST OF ROADWAY (USUALLY ℄) TO GUTTER LINE.

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STANDARD CATCH BASIN INLET CAPACITY

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CATCH BASIN SIGN DATA SHEET

PROJECT____________________ COMPUTED BY_______________ DATE __________,19____

LOCATION____________________ CHECKED BY_______________ DATE __________,19____

STORM FREQUENCY______YEARS

CATCH BASIN NO.	1 LONGITUDINAL STREET GRADE (S_L)%	2 TRANSVERSE STREET GRADE (S_T)	3 MAX. DEPTH OF OF FLOW IN GUTTER (FT.)	4 CAPACITY OF BASIN (C.F.S.) $Q=KD^{5/3}$	5 TRIAL COEF. OF RUNOFF	6 TRIAL INTENSITY (in.)	7 DERIVED AREA $=\frac{4}{5\times 6}$	8 LENGTH OF DRAINAGE AREA	9 HEIGHT ABOVE MOST REMOTE POINT	10 COEF. OF RUNOFF	11 TIME OF CONCENTRATION (T_c)	12 ACTUAL INTENSITY (in.)	13 MAX ALLOWABLE DRAINAGE AREA $=\frac{4}{10\times 12}$	REMARKS (COLUMN 13 MUST BE W/N 10% OF COLUMN 7)

REVISIONS

NO.	DATE	DESCRIPTION

CHART SD-5

APPROVED: DATE May 8, 1980

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15.16	

STORM DRAINAGE DESIGN DATA SHEET

PROJECT ____________________ DESIGNED BY ______________ DATE ____________, 19 ____

LOCATION ____________________ CHECKED BY ______________ SHEET ________ OF ________

STORM FREQUENCY ______ YEAR

LOCATION		AREA (ACRE)		C	INTENSITY			Q=CIA	PIPE DATA							[illegible]	REMARKS
FROM	TO	SUB TOTAL	TOTAL		H	L	I	(C.F.S. REQ'D)	TYPE	N	S%	LENGTH	SIZE	VEL. (OF Q REQ'D)	Q AVAIL.		

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C - RUNOFF COEFFICIENT
H - HEIGHT ABOVE INLET OF MOST REMOTE POINT
L - LENGTH OF DRAINAGE AREA
I - INTENSITY OF STORM (INCHES)
N - COEFFICIENT OF FRICTION
S - SLOPE (%)
Q - FLOW (C.F.S.)

NOTE: DESIGN IS BASED ON THE SUM OF THE AREAS AND NOT THE SUM OF THE DISCHARGES.

CHART SD-6

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COEFFICIENT OF ENTRANCE LOSS, "Ke"

TYPE OF STRUCTURE AND DESIGN OF ENTRANCE	COEFFICIENT Ke:
Pipe, Concrete	
Projecting from fill	0.5
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
Pipe or Pipe-Arch, Corrugated Metal	
Projecting (no headwall)	0.9
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
Box Reinforced Concrete	
Headwall	0.5
Wingwall at 30 degrees to 75 degrees to barrel	0.4
Wingwalls at 10 degrees to 25 degrees to barrel	0.5

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CHART SD-~~11~~ 7

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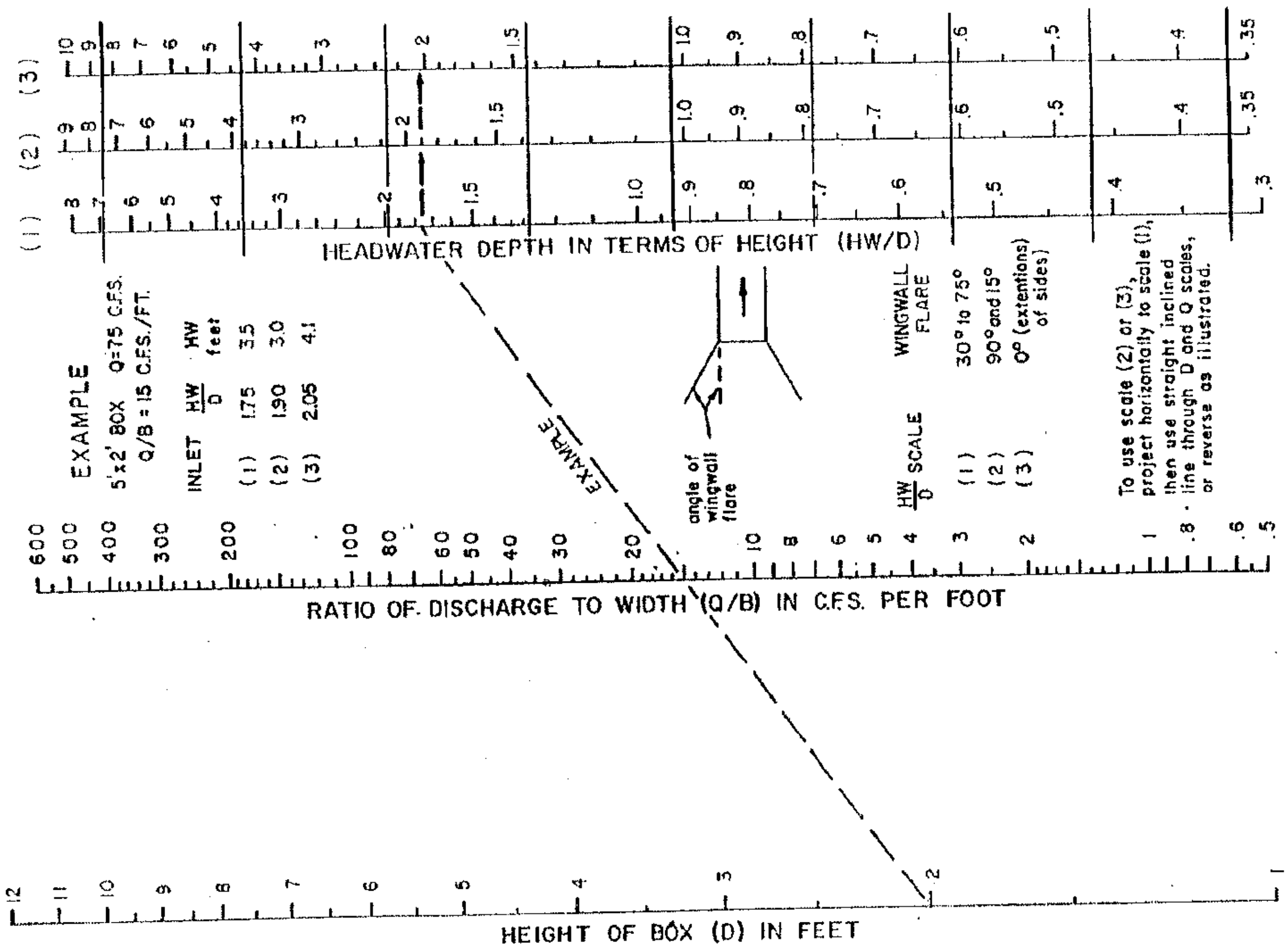
15.22	

CHART SD-a



BUREAU OF PUBLIC ROADS-JAN. 1963

REVISIONS

NO.	DATE	DESCRIPTION

HEADWATER DEPTH FOR
BOX CULVERTS WITH
INLET CONTROL

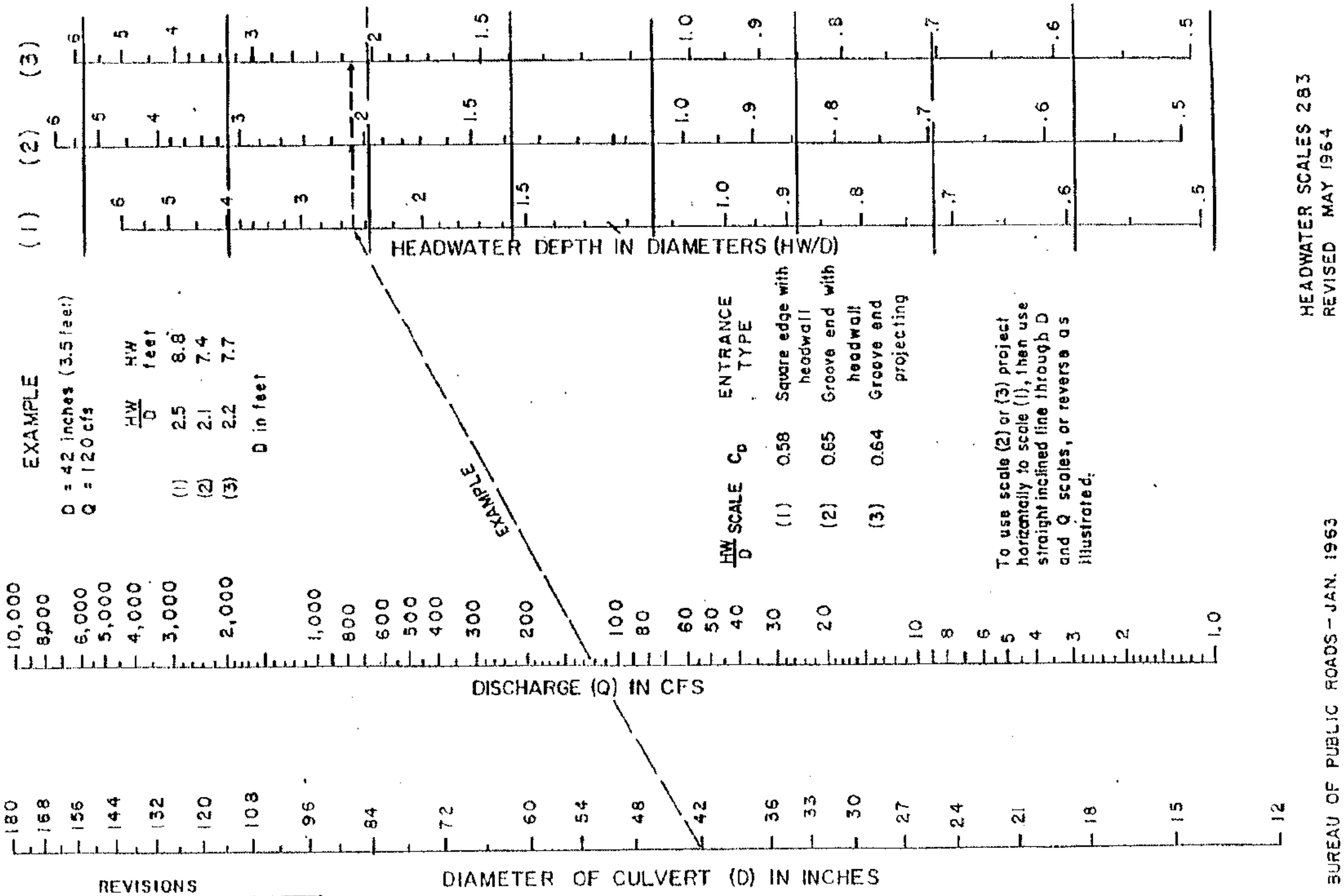
APPROVED: DATE May 8, 1980

CULVERT DESIGN– INLET CONTROL

CITY OF GREENVILLE, N.C.– ENGINEERING DEPT.

STD. NO.	REV.
15.23	

CHA SD-b



REVISIONS		
NO.	DATE	DESCRIPTION

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

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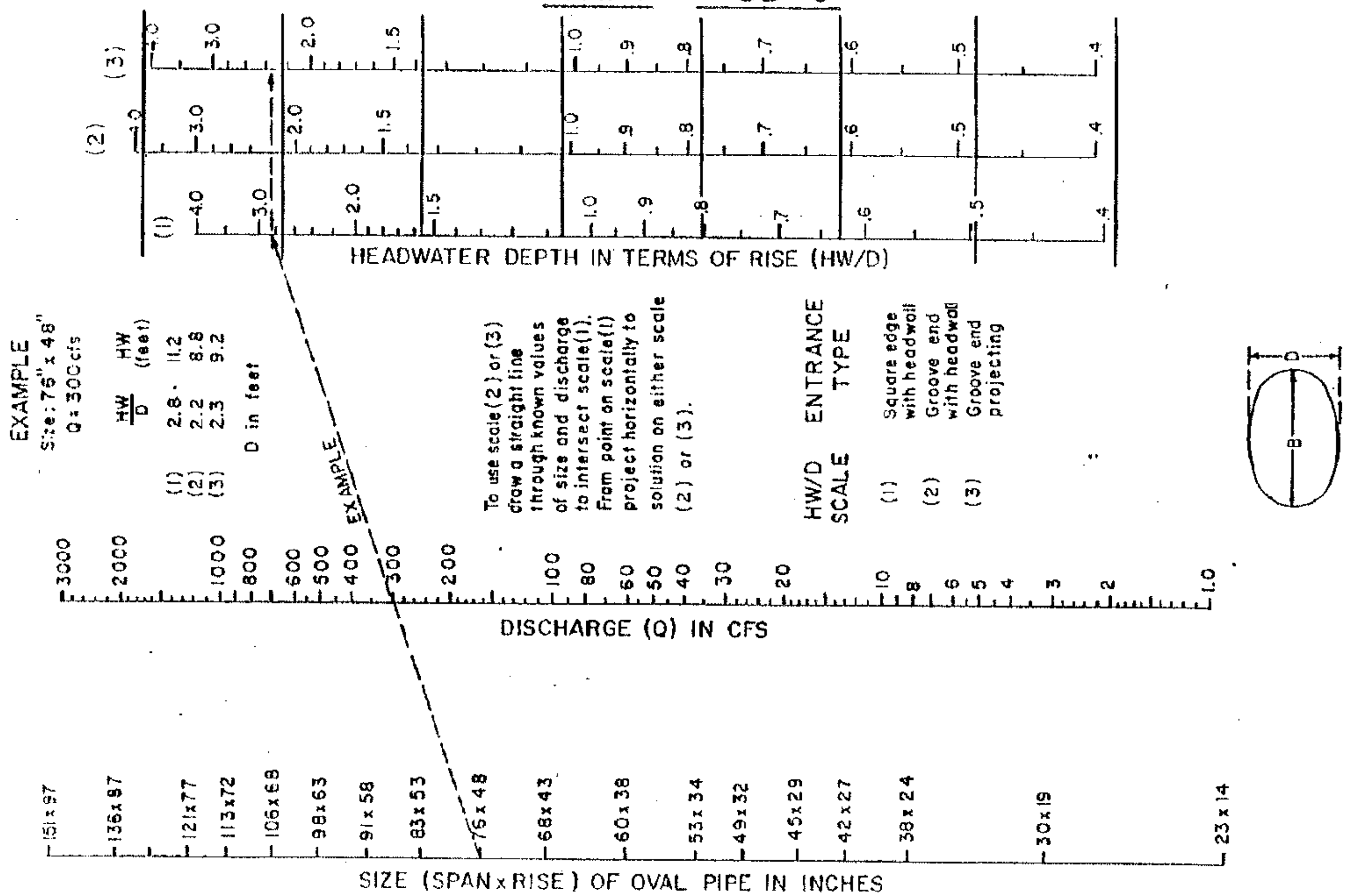
STD. NO.	REV.
15.24	

CHAF SD-c



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HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL

REVISIONS

NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

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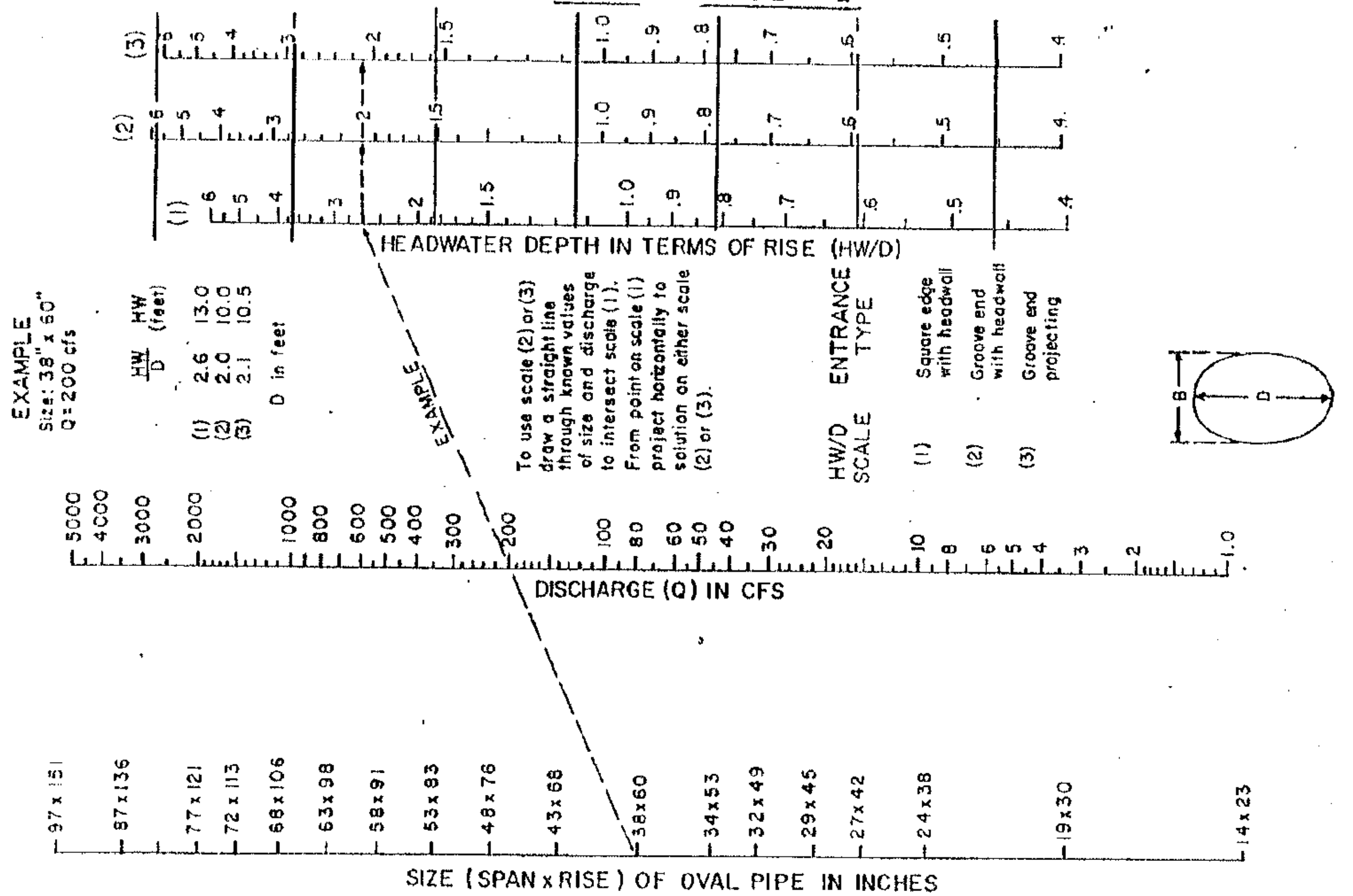
STD. NO.	REV.
15.25	

CHA SD-d



BUREAU OF PUBLIC ROADS-JAN. 1963

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS VERTICAL WITH INLET CONTROL

REVISIONS

NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

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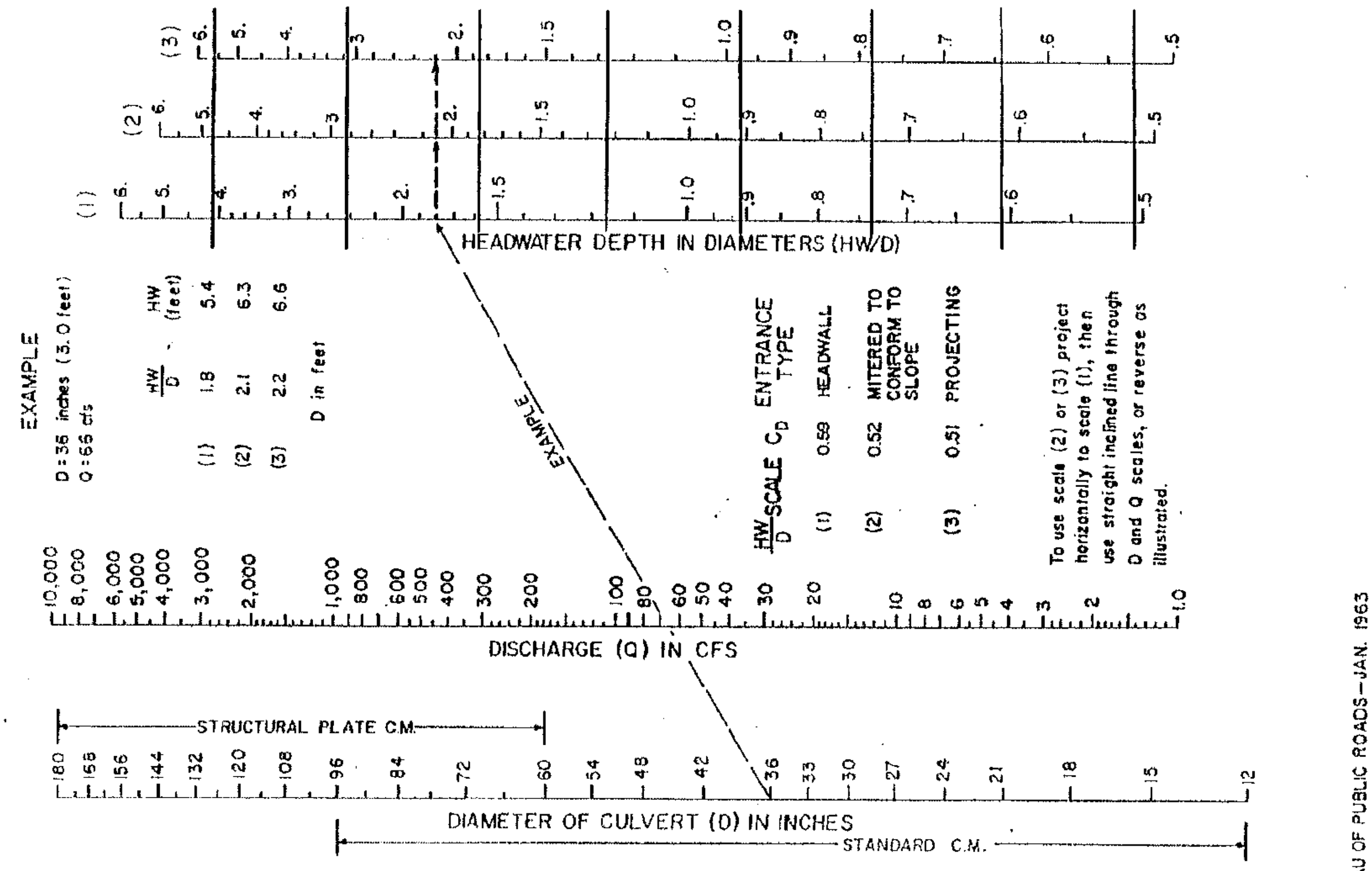
STD. NO.	REV.
15.26	

CHAI SD-e



REVISIONS		
NO.	DATE	DESCRIPTION

HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL

APPROVED: DATE May 8, 1980

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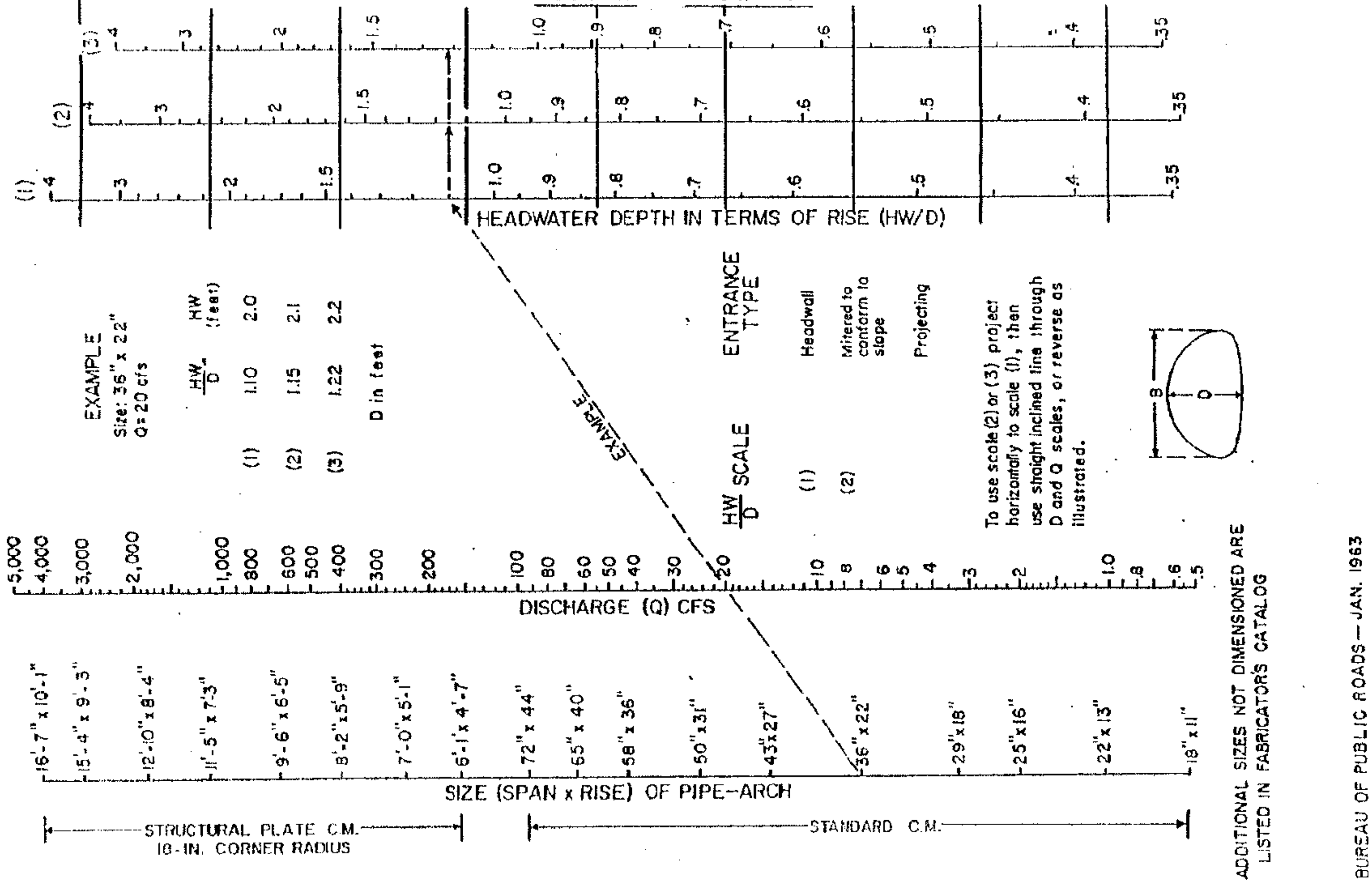
STD. NO.	REV.
1527	

CHAF .SD-f



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NO.	DATE	DESCRIPTION

HEADWATER DEPTH FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL

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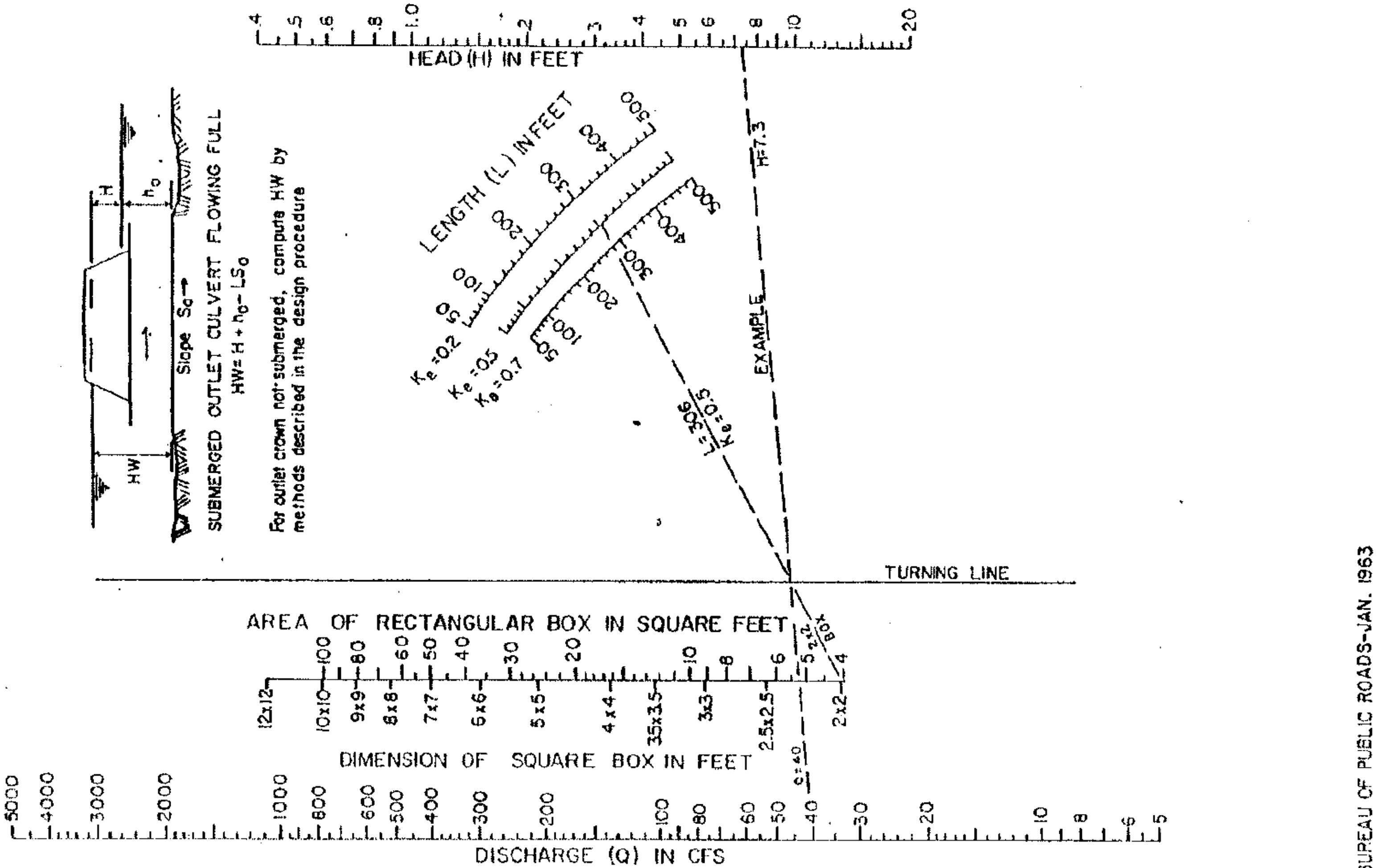
STD. NO.	REV.
15.20	

CHART SD-g



REVISIONS

NO.	DATE	DESCRIPTION

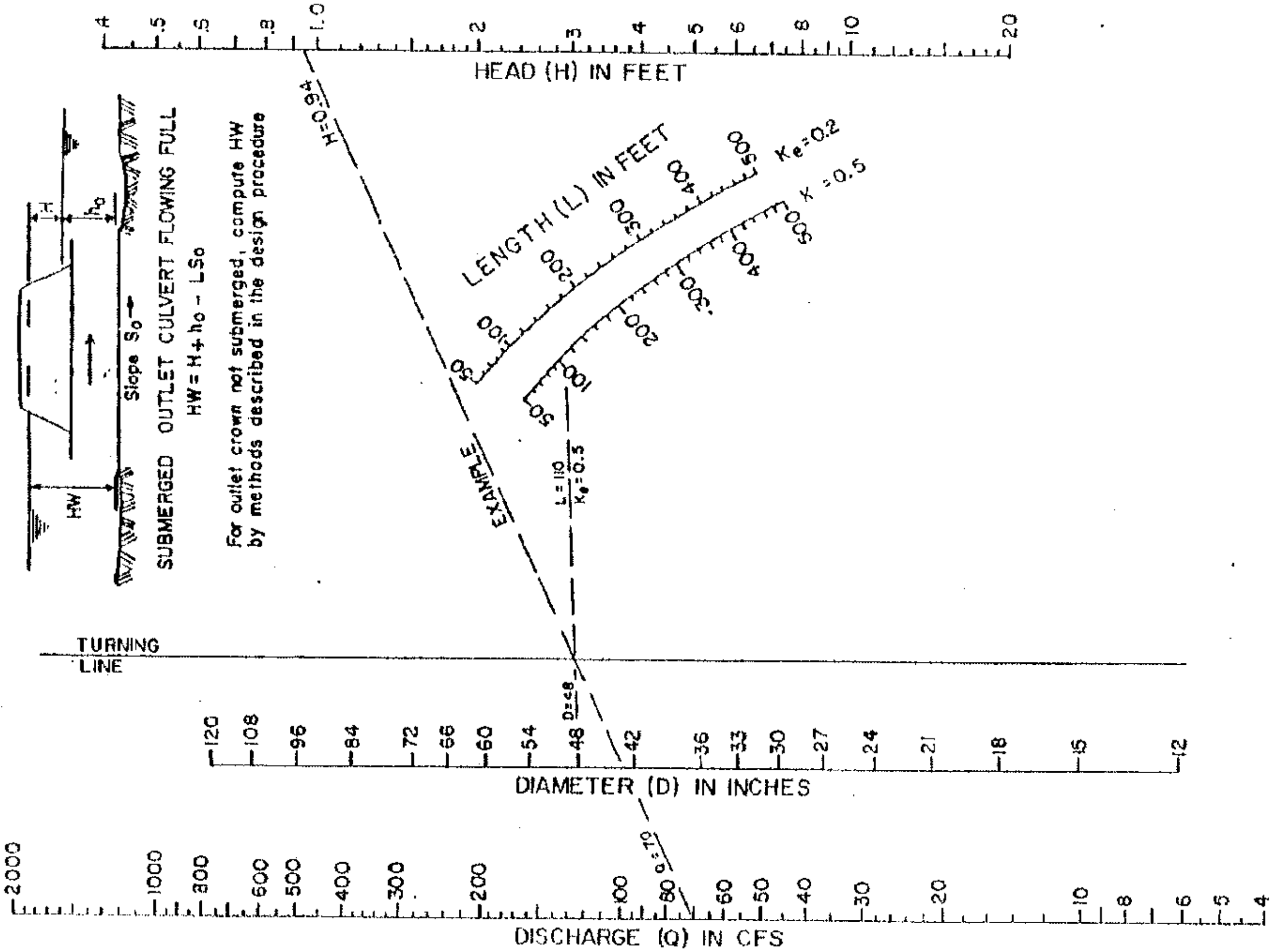
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = ~~0.012~~ 0.013

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
15.20	

CHA... SD-h



BUREAU OF PUBLIC ROADS—JAN. 1963

REVISIONS

NO.	DATE	DESCRIPTION

HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL

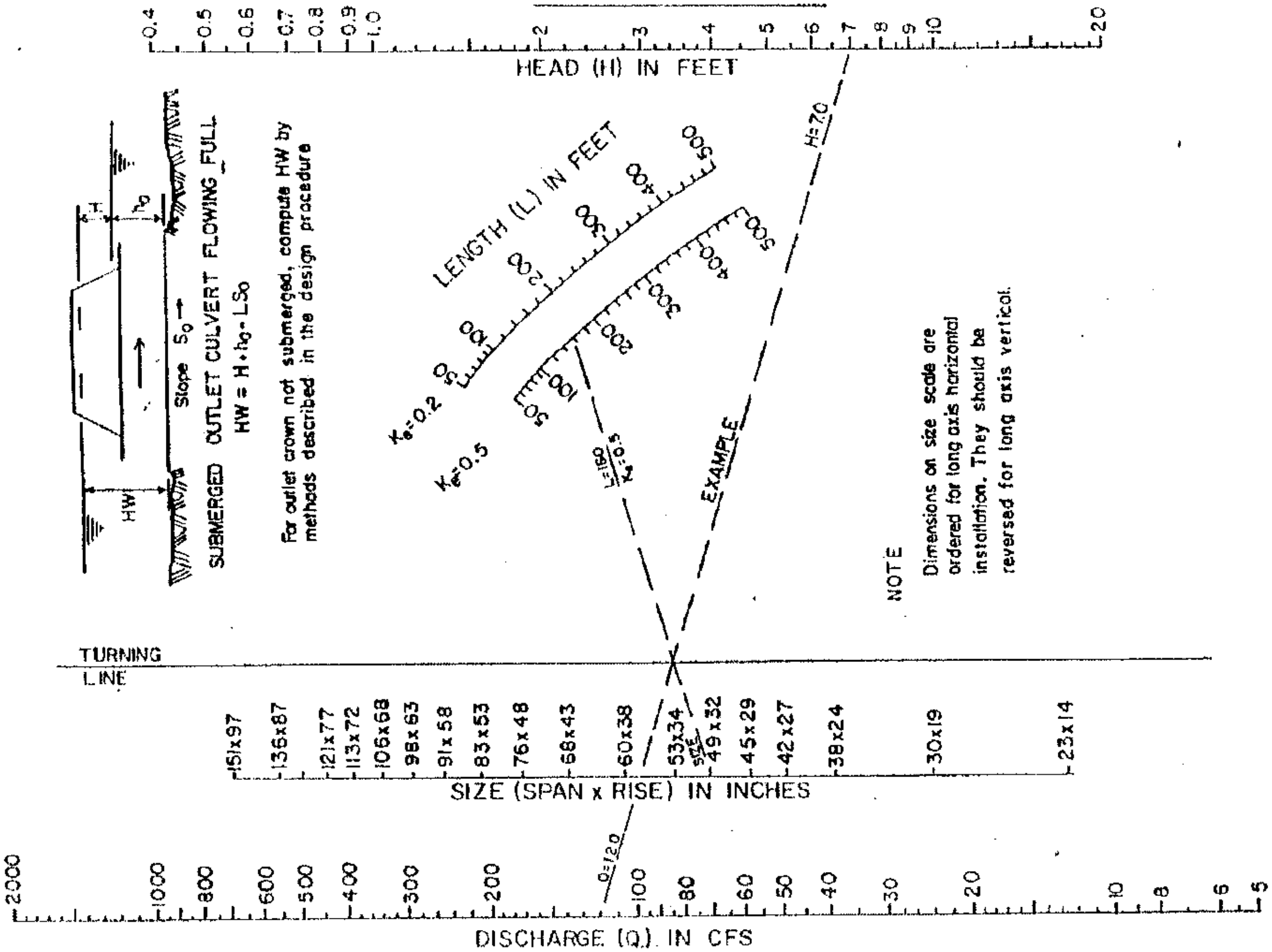
n = ~~0.012~~ 0.013

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. — ENGINEERING DEPT.

STD. NO.	REV.

CHAR.. SD-i



BUREAU OF PUBLIC ROADS – JAN. 1963

HEAD FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL OR VERTICAL FLOWING FULL

n=~~0.012~~ 0.013

REVISIONS

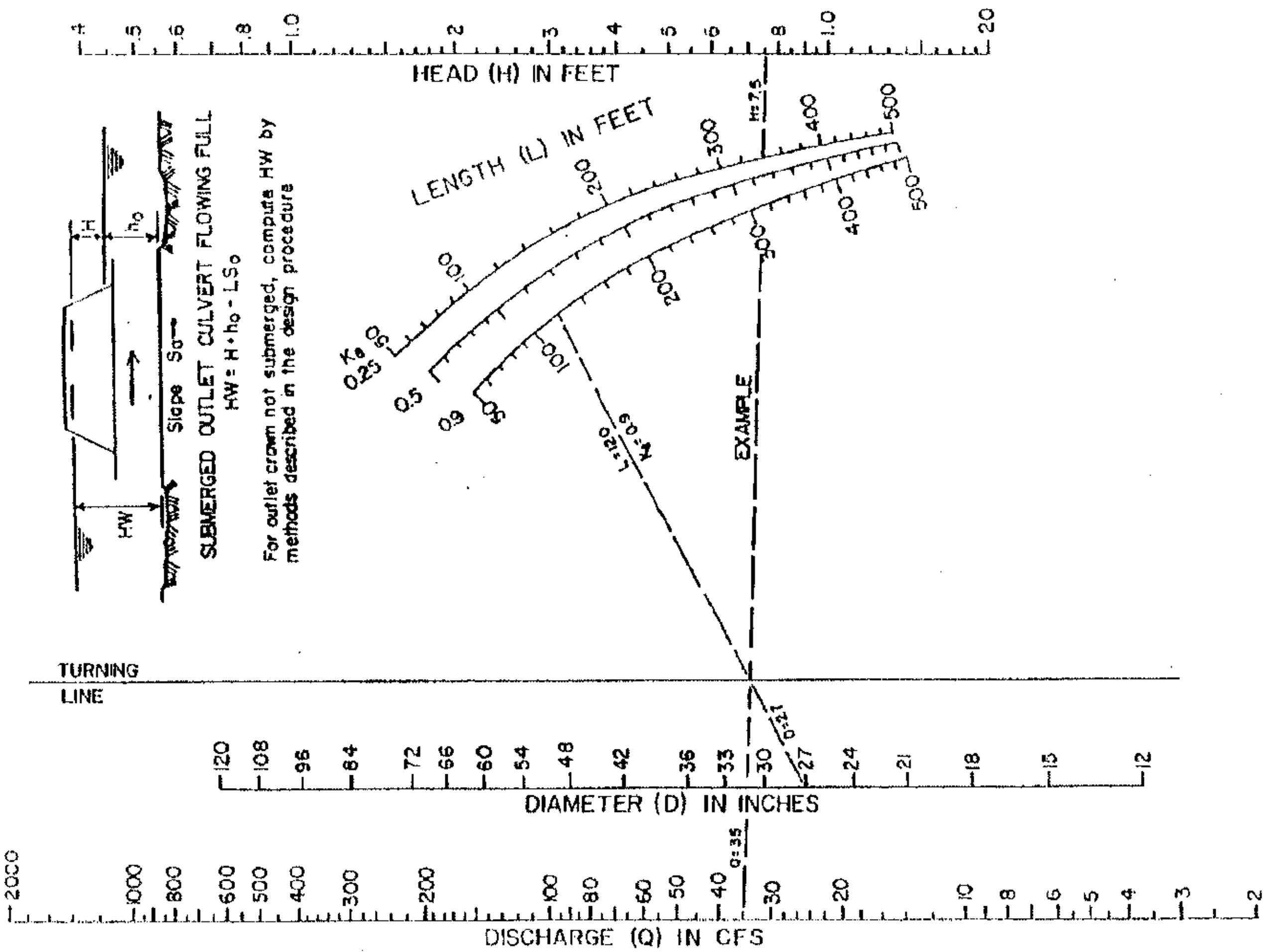
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. – ENGINEERING DEPT.

STD. NO.	REV.
15.31	

CHART SD-j



BUREAU OF PUBLIC ROADS – JAN. 1963

HEAD FOR STANDARD C. M. PIPE CULVERTS FLOWING FULL

n = ~~0.023~~ 0.024

REVISIONS

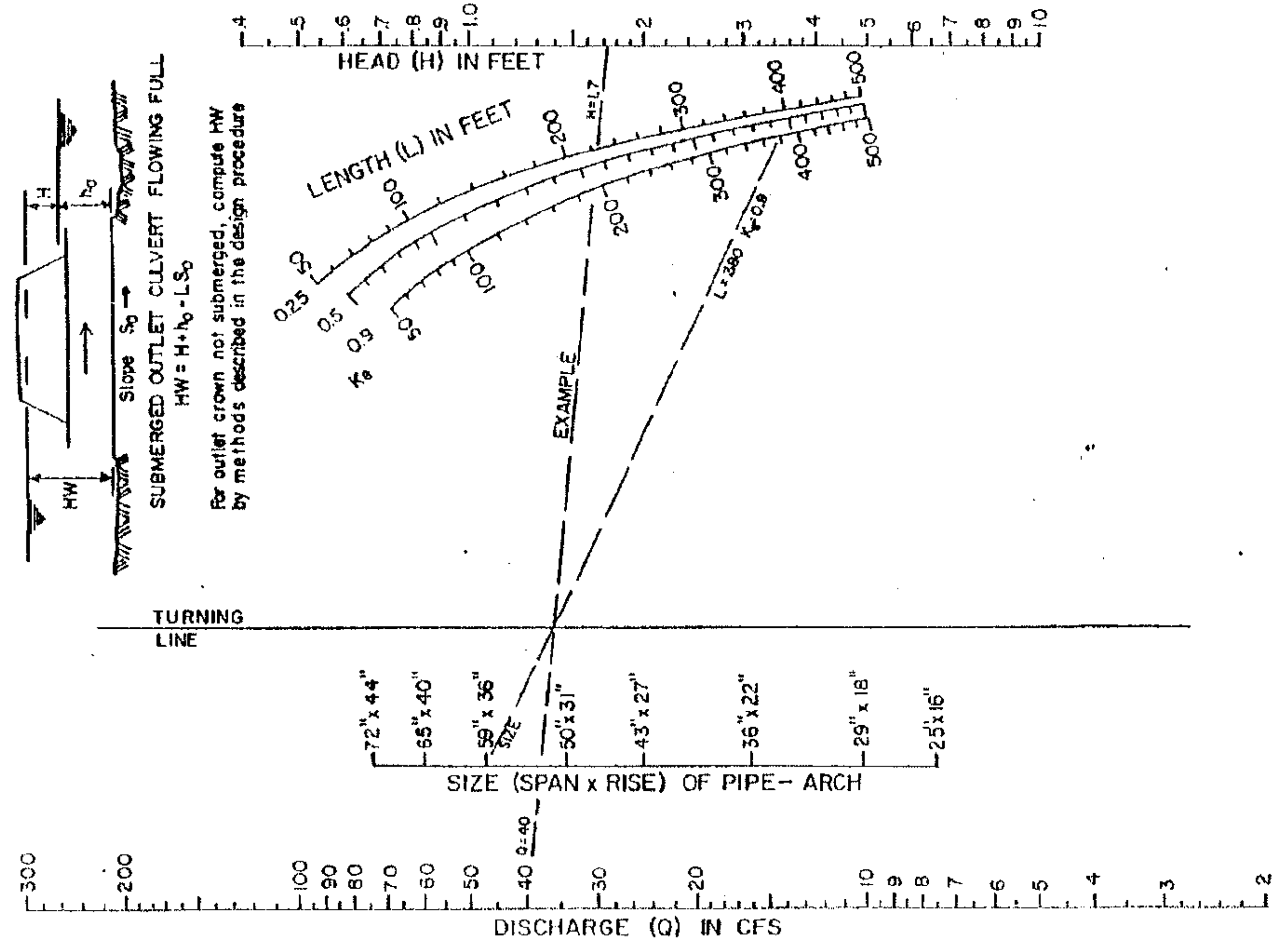
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE N.C. — ENGINEERING DEPT

STD. NO.	REV.

CHART SD-k



HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n= ~~0.023~~ 0.024

REVISIONS

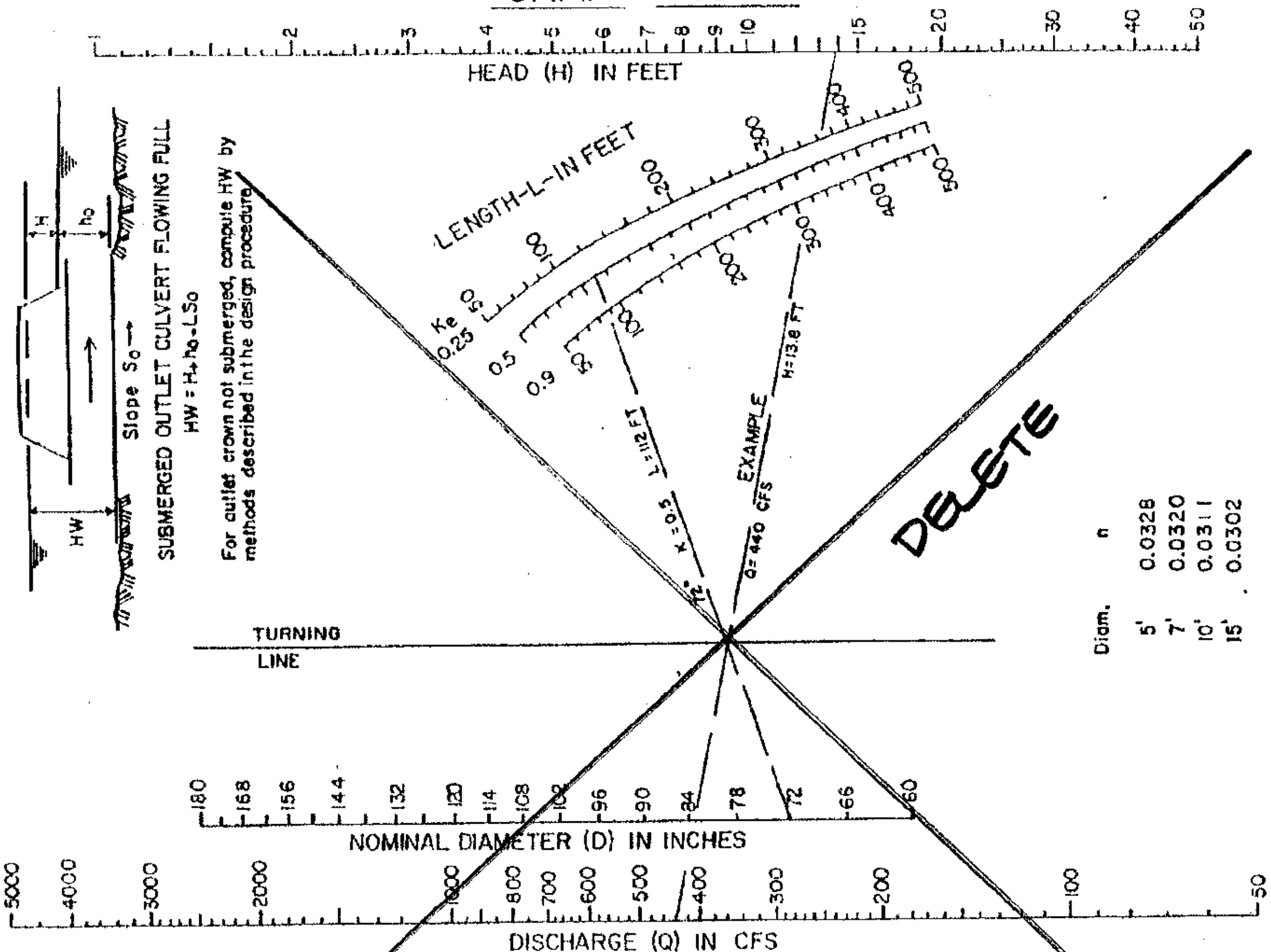
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
15.33	

CHAF. SD-1



HEAD FOR
STRUCTURAL PLATE
CORR. METAL PIPE CULVERTS
FLOWING FULL
~~n=0.0328 TO 0.0302~~

BUREAU OF PUBLIC ROADS–JAN. 1963

REVISIONS

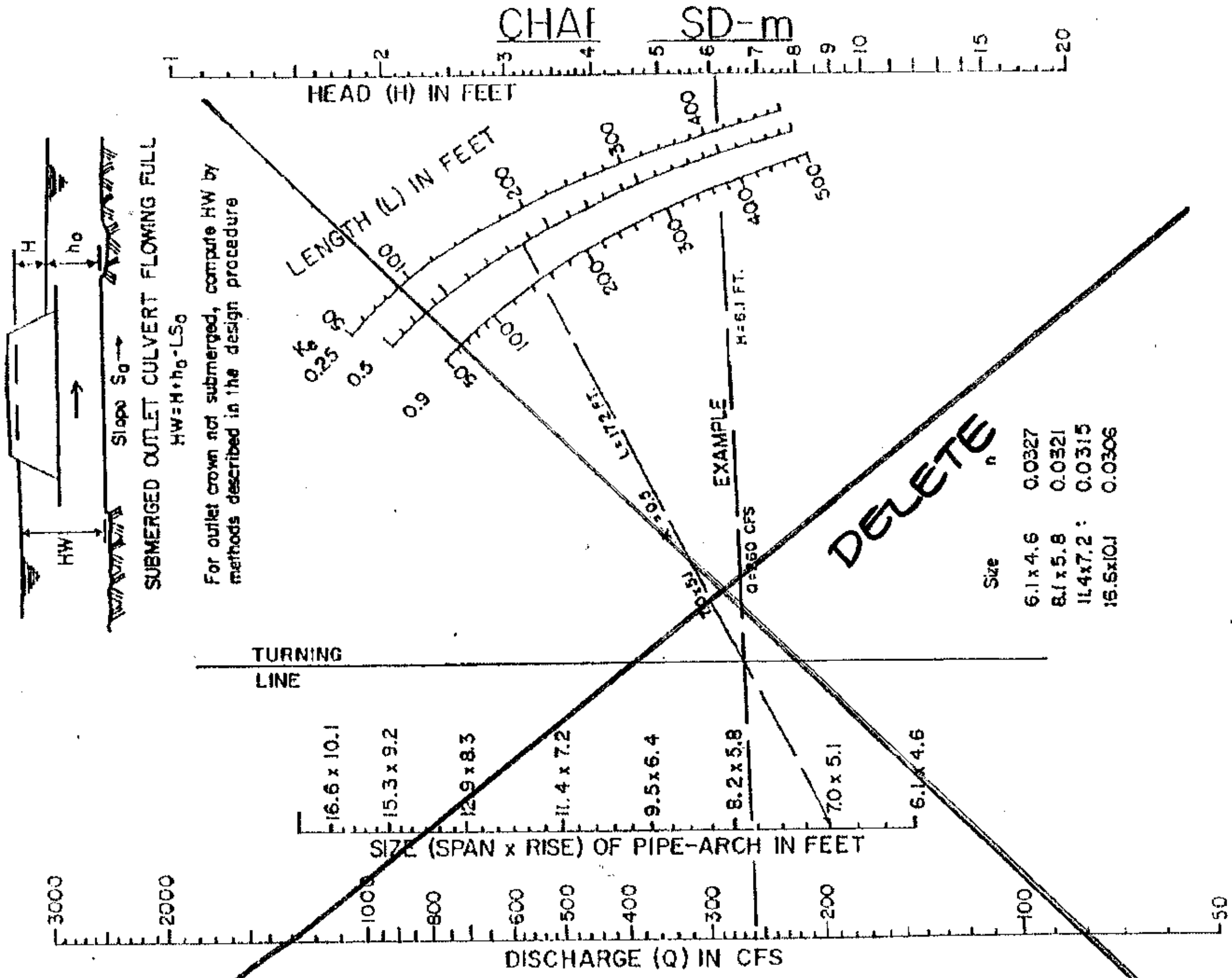
NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.

CHAF SD-m



HEAD FOR
STRUCTURAL PLATE
CORRUGATED METAL
PIPE ARCH CULVERTS
18 IN. CORNER RADIUS
FLOWING FULL
~~n=0.0327 TO 0.0306~~

REVISIONS

NO.	DATE	DESCRIPTION

APPROVED: DATE May 8, 1980

CITY OF GREENVILLE, N.C.— ENGINEERING DEPT.

STD. NO.	REV.
15 35	